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# STUDIES OF THE QUALITY OF LEATHER MADE FROM CALFSKINS OF CURRENT PACKING HOUSE PRACTICES*

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## ABSTRACT

Studies have been made to determine the quality of calfskin leather representative of two current packing house practices. In one system the skin remains on the carcass when it is placed in the cooler, to prevent shrinkage in weight of the carcass, and eventually the skin is removed in the cooler (cold pull). In the other system skinning is done immediately after slaughter (regular flay). Two lots of 120 calfskins, one of each practice, were analyzed and evaluated in the cure and as finished leather. No differences were found that could be attributed to the different practices or that indicated that one method was superior to the other as to leather quality. However, some interesting aspects of the relation of the strength of the raw stock to that of the finished leather have been noted, and such data are presented.

## INTRODUCTION

The effect of current meat-handling practices on the quality of calfskin leather never has been established, although the skins from over ten million calves slaughtered annually in this country constitute an important by-

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Material supplementary to this article, consisting of tables giving analytical and physical test data on the individual skins, has been deposited as Document No. 5805 with the ADI Auxiliary Project, Photoduplication Service, Library of Congress, Washington 25, D.C. A copy may be secured by citing the document number, and by remitting $7.50 for photoprints, or $2.75 for a 35-mm. film. Advance payment is required. Make checks or money orders payable to Chief, Photoduplication Service, Library of Congress.

second grading was done at a later date than the first and independent of the record of the first grading to eliminate bias. The skins were shipped to the Tanners' Council Research Laboratory for further testing. At the laboratory, a 6″ x 8″ piece was removed from the opposite side of each skin in a position corresponding to the one taken in the salt-cured condition. A histological assay, a chemical analysis, and physical tests were conducted on each leather piece.

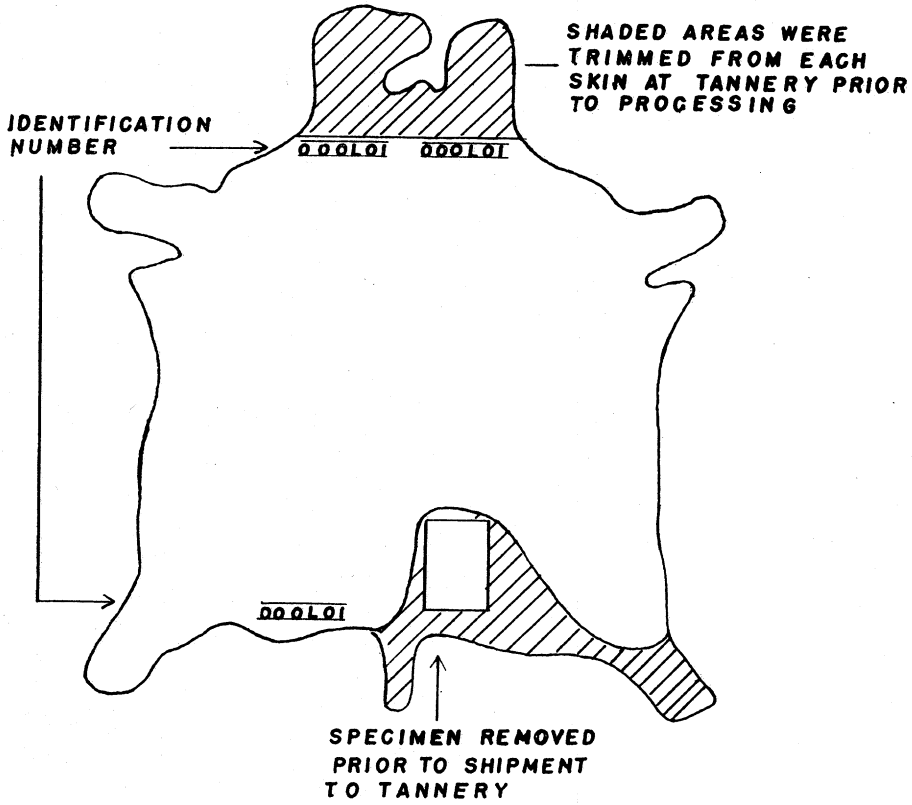


FIGURE 1

## CHARACTERISTICS OF THE SALT-CURED SKINS

For the purpose of evaluating the salt-cured skins, visual inspection, microscopic examination of cross sections, chemical analysis, and determination of tensile strength and stress-strain characteristics of each skin were conducted. By so doing it was possible to determine what differences, if any, occurred in the stock as a result of the packing house practices prior to shipping it to the tanneries for processing.

**Visual inspection.**—Each skin was inspected visually when it was spread across a sampling table at the broker's hide cellar. With the exception of the first 10 cold-pull skins, which showed some red heat, there was no condition apparent to the eye, nor any odor associated with the skins, that indicated poor cure. The skins were inspected again at the tanneries before processing. It was observed that the winter-cured skins showed no adverse effects as a result of shipment but that some of the summer-cured skins had dried areas when received at both tanneries.

**Microstructure.**—Cross sections were made of each salt-cured skin and stained for general structure and for fat in the epidermal area. A histological assay was obtained on each cross section by examination for epidermis slippage, fibroblasts in the corium, angle of the hair pocket, and deposition of fat in the epidermal area. Only 21 skins of the 240 calfskins examined showed epidermis slippage; in most of the skins the fibroblasts were still present; and the angle of the hair pocket varied in each lot—the drier the skin, the lower the angle. The deposition of the fat in the epidermal area was limited to the oil glands or their immediate vicinity and was similar for all skins, the only difference being that the larger skins contained more fat than the smaller ones. The characteristics examined for each lot were given numerical values, the total of the values constituting the histological assay of the lot. From the assays it was found that there were no significant differences among the four lots. Although microscopic examination of the 240 calfskins pointed out some imperfections, in general the individual lots of calfskins were very similar. None of the four lots showed any tendency toward alteration of the collagen fiber structure, and in most cases even the cellular structures of the skins were not unduly changed. Based on the histological assay of the salt-cured skins at the time they were ready for shipment to the tannery, it is indicated that there is no great difference in them as a result of the packing house practices of removing the skins.

**Chemical analyses of salt-cured stock.**—A portion of each 6″ x 8″ piece cut from the salt-cured skins was cut into small cubes for determining moisture, fat, protein, and total ash. An indication of quality of cure was secured through the determination of volatile nitrogen and total nitrogen. In addition each sample was analyzed for hydroxyproline as a measure of the percent collagen present.

The determinations of moisture, fat, protein, and total ash were conducted to secure a material balance of the composition of each skin. The cure "index" (3) was determined to ascertain the condition of each skin—stock with a cure index under 0.5 being a very acceptable cure. The hydroxyproline was determined in each case to obtain the percent collagen, because collagen is the only skin protein present which contains hydroxyproline.

# TABLE I

## CHEMICAL ANALYSES OF SALT-CURED SKINS

*(Ranges and average values for 30 calfskins)*

### WINTER STOCK

#### *Tannery 1*

| | Regular-Flay | | | Cold-Pull | | |
|---|---|---|---|---|---|---|
| | Range | | Average | Range | | Average |
| Moisture % | 34.42 | 47.08 | 44.98 | 34.27 | 45.52 | 41.76 |
| Fat % | 1.28 | 2.71 | 1.93 | 1.03 | 2.83 | 1.80 |
| Protein % | 32.13 | 39.46 | 35.22 | 33.31 | 42.86 | 37.25 |
| Total ash % | 15.25 | 22.54 | 17.34 | 14.48 | 22.92 | 17.19 |
| Cure index | 0.22 | 0.49 | 0.32 | 0.12 | 0.50 | 0.28 |
| Collagen % of protein | 72.4 | 83.3 | 77.6 | 68.3 | 81.2 | 74.3 |

#### *Tannery 2*

| | | | | | | |
|---|---|---|---|---|---|---|
| Moisture % | 23.66 | 45.09 | 41.83 | 23.50 | 45.38 | 40.67 |
| Fat % | 1.35 | 4.07 | 2.74 | 1.85 | 4.53 | 2.56 |
| Protein % | 34.17 | 53.62 | 38.21 | 34.90 | 55.02 | 40.33 |
| Total ash % | 15.54 | 20.46 | 17.03 | 11.23 | 22.77 | 15.95 |
| Cure index | 0.21 | 0.41 | 0.34 | 0.26 | 0.38 | 0.32 |
| Collagen % of protein | 67.2 | 82.2 | 74.7 | 66.1 | 82.7 | 74.1 |

### SUMMER STOCK

#### *Tannery 1*

| | | | | | | |
|---|---|---|---|---|---|---|
| Moisture % | 42.58 | 48.69 | 46.09 | 40.50 | 46.37 | 44.78 |
| Fat % | 1.57 | 5.22 | 2.80 | 1.27 | 4.55 | 2.59 |
| Protein % | 33.66 | 42.82 | 36.20 | 35.57 | 42.43 | 38.32 |
| Total ash % | 9.66 | 15.89 | 14.20 | 12.21 | 15.01 | 14.02 |
| Cure index | 0.06 | 0.37 | 0.18 | 0.19 | 0.49 | 0.34 |
| Collagen % of protein | 68.6 | 86.3 | 77.5 | 69.0 | 86.9 | 76.0 |

#### *Tannery 2*

| | | | | | | |
|---|---|---|---|---|---|---|
| Moisture % | 41.62 | 47.15 | 45.42 | 40.79 | 48.12 | 44.82 |
| Fat % | 1.19 | 4.80 | 2.67 | 1.29 | 4.04 | 2.08 |
| Protein % | 33.05 | 42.21 | 37.34 | 36.08 | 41.93 | 39.21 |
| Total ash % | 12.24 | 15.26 | 14.12 | 12.10 | 15.53 | 13.81 |
| Cure index | 0.11 | 0.35 | 0.24 | 0.25 | 0.46 | 0.37 |
| Collagen % of protein | 68.7 | 88.0 | 75.6 | 66.1 | 81.9 | 74.5 |

The chemical analyses of the calfskins are given in Table I. Each average value in the table represents 30 individual determinations; the ranges show the spread from the average. Examination of the data for moisture, fat, protein, and total ash shows that there is variation from skin to skin as to composition from the standpoint of all components. This variation in chemical composition occurs for all four lots of skins. While there is variation in chemical composition within a lot, when the range of values and average values are examined, it is seen that there is little difference in the summer- or winter-cured skins. The cure index indicates that all four lots of calfskins were well cured, and the percentage of collagen is similar for all four lots. The summer-cured skins have a higher average moisture content and a lower salt content, with the average protein content and fat content being the same for the summer- and winter-cured stocks.

Examination of the average chemical composition of the regular-flay stock versus the cold-pull stock indicates that there are no material differences in the two stocks. When the average value and range are compared, it can be seen that the stocks are similar as to moisture content, fat, collagen, and amount of salt present.

**Strength of salt-cured stock.**—From the 6″ x 8″ piece cut from each salt-cured skin, specimens for tensile strength, stress-strain characteristics, and bursting strength were secured. The object of determining strength characteristics of the salt-cured stock was to discover any differences which may occur due to the two packing house practices. To find out whether the strength characteristics may be altered by subsequent processing, the physical strength characteristics of the finished leather also were determined.

Prior to determining tensile strength, the specimens were measured for thickness in thousandths of an inch using the Randall-Stickney gauge. The tensile strength and stress-strain specimens were run on the Instron Tester using a 10-inch pulling speed, a chart speed of 50 inches per minute for measuring stretch, a 2-inch span between jaws, and a 500-pound full load. The stretch as well as the breaking load was recorded on the chart in each case.

The tensile strength and percent stretch values of the calfskins are given in Table II. Each average value in the table represents 30 individual determinations, and the ranges in each case show the spread from the average. Examination of the average tensile strength values in pounds per square inch for the regular flayed stock shows values of 3835, 2828, 3780, and 3418 lb. per sq. in. The values for the cold-pull stock were 3608, 2879, 2940, and 3078 lb. There is little difference in the tensile strength of the winter stock sent to Tannery 1, the average values being 3835 lb. for the regular flayed stock and 3608 lb. for the cold-pull stock. There is little difference in the tensile strength of the winter stock shipped to Tannery 2, the average values

## TABLE II

TENSILE STRENGTH AND PERCENT STRETCH OF SALT-CURED SKINS

*(Ranges and average values for 30 calfskins)*

| | Regular-Flay | | | Cold-Pull | | |
|---|---|---|---|---|---|---|
| | Range | | Average | Range | | Average |
| **WINTER STOCK** | | | | | | |
| *Tannery 1* | | | | | | |
| Lb. at break | 112 | 230 | 165 | 95 | 215 | 153 |
| Thickness (inch) | .061 | .111 | .087 | .060 | .128 | .090 |
| % stretch | 44.0 | 76.0 | 58.7 | 35.0 | 68.0 | 53.2 |
| Lb. per sq. in. | 2760 | 5410 | 3835 | 2650 | 5330 | 3608 |
| *Tannery 2* | | | | | | |
| Lb. at break | 67 | 168 | 124 | 67 | 195 | 135 |
| Thickness (inch) | .050 | .122 | .090 | .062 | .127 | .094 |
| % stretch | 41.0 | 76.0 | 60.0 | 42.0 | 88.0 | 65.0 |
| Lb. per sq. in. | 1810 | 3500 | 2828 | 1440 | 3910 | 2879 |
| **SUMMER STOCK** | | | | | | |
| *Tannery 1* | | | | | | |
| Lb. at break | 130 | 265 | 198 | 105 | 225 | 150 |
| Thickness (inch) | .078 | .131 | .105 | .070 | .146 | .102 |
| % stretch | 37.0 | 81.0 | 61.0 | 38.0 | 75.0 | 57.0 |
| Lb. per sq. in. | 2310 | 4950 | 3780 | 2190 | 4270 | 3010 |
| *Tannery 2* | | | | | | |
| Lb. at break | 145 | 230 | 188 | 98 | 201 | 153 |
| Thickness (inch) | .084 | .145 | .111 | .080 | .155 | .101 |
| % stretch | 58.0 | 91.0 | 71.0 | 45.0 | 98.0 | 63.7 |
| Lb. per sq. in. | 2410 | 4820 | 3418 | 2250 | 4270 | 3078 |

being 2828 lb. for the regular flayed stock and 2879 lb. for the cold-pull stock, but these values indicate lower average strength for the stock received at Tannery 2.

In the case of the summer-cured stock, the average tensile strength of the cold-pull stock (3010 and 3078 lb. per sq. in.) is lower than that of the regular flayed stock, which had average values of 3780 and 3418 lb. No evidence is available from the work performed as to whether the differences are due to

## TABLE III

### STRESS-STRAIN CHARACTERISTICS OF SALT-CURED SKINS

*(Range and average values for 30 calfskins stretched 37.5%, relaxed, and then stretched to break)*

| | Regular-Flay | | | Cold-Pull | | |
|---|---|---|---|---|---|---|
| | Range | | Average | Range | | Average |
| **WINTER STOCK** | | | | | | |
| *Tannery 1* | | | | | | |
| Lb. at break | 82 | 200 | 156 | 95 | 195 | 147 |
| Lb. at 37.5% | 40 | 140 | 82 | 55 | 117 | 81 |
| % stretch | 42 | 85 | 62 | 45 | 75 | 59 |
| Lb. per sq. in. | 2500 | 4610 | 3434 | 2450 | 5060 | 3345 |
| *Tannery 2* | | | | | | |
| Lb. at break | 85 | 195 | 139 | 66 | 210 | 130 |
| Lb. at 37.5% | 43 | 110 | 64 | 44 | 98 | 68 |
| % stretch | 46 | 86 | 68 | 51 | 80 | 66 |
| Lb. per sq. in. | 2160 | 5060 | 3075 | 2160 | 3800 | 2770 |
| **SUMMER STOCK** | | | | | | |
| *Tannery 1* | | | | | | |
| Lb. at break | 120 | 230 | 189 | 85 | 200 | 151 |
| Lb. at 37.5% | 60 | 150 | 115 | 45 | 140 | 89 |
| % stretch | 44 | 90 | 62 | 45 | 83 | 62 |
| Lb. per sq. in. | 2660 | 4630 | 3407 | 1900 | 4240 | 2970 |
| *Tannery 2* | | | | | | |
| Lb. at break | 140 | 250 | 180 | 120 | 190 | 148 |
| Lb. at 37.5% | 35 | 110 | 77 | 35 | 110 | 75 |
| % stretch | 60 | 95 | 72 | 49 | 94 | 65 |
| Lb. per sq. in. | 2380 | 4310 | 3198 | 2240 | 3840 | 2959 |

the two packing house practices or to the handling of the skins after being removed from the carcasses, or whether they are characteristic of the animals from which the skins were taken.

The stress-strain test results of the winter and summer stocks are given in Table III. By extending the specimens to 37.5% elongation, allowing them to relax, and then extending them to break, there is a tendency to lower the average tensile strength values somewhat in all but the 30 skins of the regular-flay stock sent to Tannery 2. In comparing the values in Tables

II and III the regular-flay stock in Table II has average tensile strength values of 3835, 2828, 3780, and 3418 lb. per sq. in. compared with the values in Table III (specimens after straining before break and then breaking) of 3434, 3075, 3407, and 3198 lb. The cold-pull stock in Table II has average tensile strength values of 3608, 2879, 3010, and 3078 lb. per sq. in. compared to the values in Table III of 3345, 2770, 2970, and 2959 lb. Apparently when the salt-cured stock has a value of approximately 3000 or lower, the straining of the specimen to a constant extension of 37.5% and allowing it to relax before breaking does not alter the stock enough to prevent its recovery, whereas the specimens with the higher strength are definitely weakened, which results in lower tensile strength values upon applying strain before extending to break.

## TANNERY EVALUATION

At each tannery the leathers made from the skins were graded for temper, grain break, veins, and grain characteristics, as well as for selling grade. At Tannery 1 the grading values obtained by two graders were averaged and submitted on this basis. At Tannery 2 the individual gradings made were submitted as such. The selling-grade values did not depend necessarily on the above determined characteristics but were very much dependent upon the useable area of the leather. Examination of the values given to the characteristics of the leather and to the selling-grade values indicated that there were no noticeable differences among the four lots of leather or between the leathers from the summer and winter stocks, based on the observations of the four graders at the two tanneries.

**Microstructure of the leathers.**—Cross sections were made of the leather from each of the 120 summer-cured skins processed at the two tanneries. The cross sections were measured for the curvature of grain side, hair pocket angle, and dye penetration.

The 60 calfskin leathers prepared at Tannery 1 showed little difference in the curvature of the grain and the hair pocket angle when the leather from the regular-flay versus the leather from the cold-pull calfskins were compared. The leather of the cold-pull calfskins showed greater dye penetration. There was little difference in the curvature of the grain, the hair pocket angle, or dye penetration of the regular-flay versus the cold-pull leather specimens from Tannery 2. The values obtained in the assay showed all the leathers from both tanneries to have similar characteristics, with only the dye penetration of the cold-pull stock from Tannery 1 being somewhat greater than observed in the other leathers.

**Chemical analyses of leathers.**—A portion of each 6″x 8″ piece taken from each skin was cut into cubes and ground in a Wiley mill to pass through a 4-mm. screen. This ground leather sample was used to determine moisture,

grease, hide substance, chromic oxide, and pH. The chromic oxide content was multiplied by 2.73, the "Kubelka factor" (1, 2), to calculate the content of chrome tanning agent. The chemical analyses of the leathers are given in Table IV. Examination of the data for grease, hide substance, and chrome tanning agent shows that there is variation in each lot as to composition but that the range of values is similar. Comparison of the data in Table IV indi-

## TABLE IV

### CHEMICAL ANALYSES OF LEATHERS

*(Range and average values for 30 calfskins)*

| | Regular-Flay | | | Cold-Pull | | |
|---|---|---|---|---|---|---|
| | Range | | Average | Range | | Average |
| **WINTER STOCK** | | | | | | |
| *Tannery 1* | | | | | | |
| Grease % | 3.17 | 4.80 | 3.90 | 2.83 | 5.87 | 4.24 |
| Hide substance % | 81.11 | 84.48 | 82.60 | 78.45 | 85.36 | 82.28 |
| Chrome tannage % | 11.08 | 15.01 | 13.34 | 10.54 | 15.12 | 13.21 |
| pH | 3.62 | 4.73 | 3.76 | 3.51 | 3.90 | 3.71 |
| *Tannery 2* | | | | | | |
| Grease % | 3.31 | 5.12 | 4.08 | 3.09 | 4.92 | 4.02 |
| Hide substance % | 80.04 | 84.57 | 82.78 | 81.23 | 86.09 | 82.99 |
| Chrome tannage % | 11.08 | 12.69 | 12.15 | 10.67 | 12.53 | 12.09 |
| pH | 3.03 | 3.53 | 3.32 | 3.23 | 3.42 | 3.30 |
| **SUMMER STOCK** | | | | | | |
| *Tannery 1* | | | | | | |
| Grease % | 3.45 | 5.57 | 4.45 | 3.51 | 6.36 | 4.45 |
| Hide substance % | 80.96 | 86.09 | 82.49 | 77.73 | 84.81 | 82.23 |
| Chrome tannage % | 11.14 | 12.53 | 12.09 | 12.18 | 14.96 | 13.46 |
| pH | 3.22 | 3.40 | 3.30 | 3.47 | 4.03 | 3.59 |
| *Tannery 2* | | | | | | |
| Grease % | 3.04 | 6.03 | 4.54 | 3.24 | 6.72 | 3.95 |
| Hide substance % | 79.33 | 86.62 | 82.80 | 82.23 | 85.69 | 83.96 |
| Chrome tannage % | 12.07 | 14.58 | 13.47 | 10.54 | 11.85 | 11.36 |
| pH | 3.50 | 3.86 | 3.59 | 3.35 | 3.48 | 3.42 |

## TABLE V

### TENSILE STRENGTH AND PERCENT STRETCH OF LEATHER

*(Range and average for 30 calfskins)*

| | Regular-Flay | | | Cold-Pull | | |
|---|---|---|---|---|---|---|
| | Range | | Average | Range | | Average |
| **WINTER STOCK** | | | | | | |
| *Tannery 1* | | | | | | |
| Lb. at break | 55 | 133 | 93 | 70 | 125 | 99 |
| Thickness (inch) | .039 | .059 | .050 | .028 | .074 | .049 |
| % stretch | 25 | 57 | 39 | 26 | 58 | 36 |
| Lb. per sq. in. | 2620 | 5130 | 3755 | 2190 | 6640 | 4091 |
| *Tannery 2* | | | | | | |
| Lb. at break | 43 | 97 | 62 | 36 | 97 | 67 |
| Thickness (inch) | .027 | .053 | .041 | .028 | .057 | .042 |
| % stretch | 27 | 58 | 39 | 26 | 52 | 39 |
| Lb. per sq. in. | 2300 | 4510 | 3048 | 2440 | 4220 | 3176 |
| **SUMMER STOCK** | | | | | | |
| *Tannery 1* | | | | | | |
| Lb. at break | 40 | 115 | 79 | 40 | 105 | 74 |
| Thickness (inch) | .032 | .065 | .051 | .033 | .066 | .048 |
| % stretch | 30 | 60 | 45 | 33 | 82 | 47 |
| Lb. per sq. in. | 2100 | 4370 | 3111 | 2240 | 3780 | 3120 |
| *Tannery 2* | | | | | | |
| Lb. at break | 42 | 120 | 76 | 50 | 98 | 75 |
| Thickness (inch) | .041 | .068 | .053 | .042 | .067 | .052 |
| % stretch | 32 | 60 | 47 | 35 | 76 | 51 |
| Lb. per sq. in. | 1820 | 4000 | 2868 | 1850 | 4090 | 2943 |

cates that there is practically no difference in the average chemical composition of the regular-flay versus the cold-pull calfskin leathers. There is variation in acidity of the leathers, but this represents plant practices.

**Strength of the leathers.**—From each 6″ x 8″ piece taken from each skin, specimens were cut for determining tensile strength, percent stretch at break, and stress-strain characteristics, by the procedure used for the salt-cured skin specimens. The tensile strength and percent stretch at break for the 240 leathers are given as average and range values in Table V. Examina-

results there was no difference in strength properties brought about by tannery practices.

The stress-strain characteristics of the regular-flay and cold-pull calfskin leather specimens processed at the two tanneries are given in Table VI. Upon extending the specimens to 37.5% (which was the extension selected for the salt-cured calfskins), allowing them to relax, and then extending them to break, there was no tendency toward lowering of the tensile strength as observed in the case of the salt-cured skins. In comparing the values in Tables V and VI the regular-flay stock in Table V has average tensile strength values of 3755, 3048, 3111, and 2868 lb. per sq. in. compared to the values in Table VI (specimens after strain before break and then breaking) of 3931, 3135, 3109, and 2653 lb. The cold-pull stock in Table V has average tensile strength values of 4091, 3176, 3120, and 2943 lb. per sq. in. compared to the values in Table VI of 4330, 3131, 3121, and 2832 lb. When the values for percent stretch at break are compared, it is observed that the summer stock

TABLE VII

COMPARISON OF THE STRENGTH IN POUNDS OF REGULAR-FLAY AND COLD-PULL CALFSKINS AND LEATHERS

| Regular-Flay | | Cold-Pull | |
|---|---|---|---|
| **WINTER STOCK** | | | |
| *Tannery 1* | | | |
| Skin | 165 | Skin | 153 |
| Leather | 93 | Leather | 99 |
| *Tannery 2* | | | |
| Skin | 129 | Skin | 135 |
| Leather | 62 | Leather | 67 |
| **SUMMER STOCK** | | | |
| *Tannery 1* | | | |
| Skin | 198 | Skin | 150 |
| Leather | 79 | Leather | 74 |
| *Tannery 2* | | | |
| Skin | 188 | Skin | 150 |
| Leather | 76 | Leather | 74 |

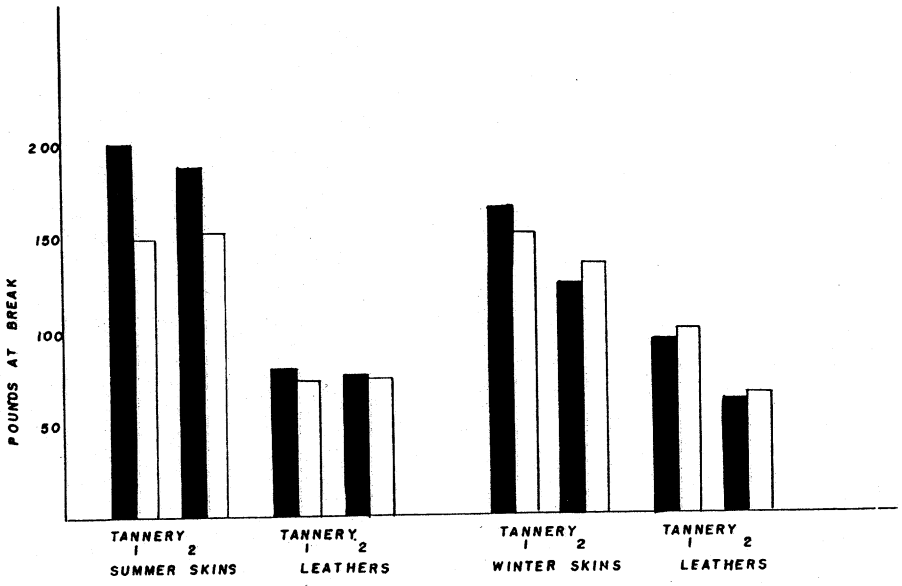


FIGURE 2.—Tensile strength. Pounds at break. Regular flay in black; cold pull in white.

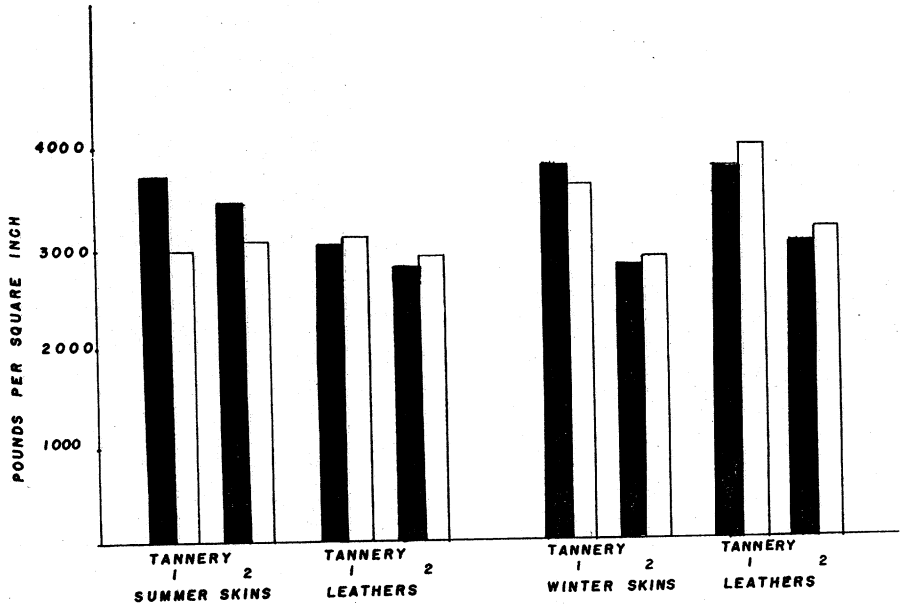


FIGURE 3.—Tensile strength. Pounds per square inch at break. Regular flay in black; cold pull in white.

Examination of the data in Table VIII shows that the winter skins processed at Tannery 1 have comparable tensile strengths as leathers irrespective of whether they were hot-flay or cold-pull skins. The winter skins processed at Tannery 2 have lower initial strength irrespective of take-off practices than those sent to Tannery 1, but they have comparable tensile strength as leather.

The regular-flay summer skins processed at both tanneries show a reduction in tensile strength when made into leather. Seemingly, this reduction may be the result of processing at both tanneries, but just what it reflects is not known from our present experimental plan. The reduction in thickness due to processing is not the only factor involved in the reduction of strength in this case. The cold-pull summer skins processed at each tannery do not show a reduction in strength as a result of processing but had lower strength than the regular-flay skins before being received at the tanneries.

The data in Tables VII and VIII are given in bar-graph form in Figs. 2 and 3. These figures bear out the observations mentioned above and also show that the summer stock of the regular-flay calfskins requires a greater number of pounds to break it than is necessary for the cold-pull calfskins. This difference is not observed in the leathers. Although the reduction of tensile strength of the regular-flay stock is readily observed, in the case in the winter skins, processing into leather has not decreased the tensile strength.

From the elongation curves of the leather specimens used for tensile-strength measurements, the average values of load at 10, 20, and 30% extensions were used to give the curves shown in Figs. 4 and 5. In Fig. 4 the curves for the stock processed at Tannery 1 are given. When the regular-flay versus the cold-pull calfskin leather specimens are compared, it is observed that the summer stock is more readily extended than the winter stock, requires less load in pounds to extend the leathers, and breaks at a greater extension but at lower loads.

The curves for the stock processed at Tannery 2 are given in Fig. 5. These leathers have similar properties for both summer and winter cure and are similar to the summer-cured stock processed at Tannery 1. The winter stock processed at Tannery 1 is less extensible than the other six lots.

From the stress-strain curves, where the stock was extended first to 37.5%, allowed to relax, and then stretched to 40% again, the curves in Figs. 6 and 7 were plotted. These curves reflect the permanent set put into the stock as a result of the first extension prior to extending the specimens again, and it is observed that the leather is more stretchy on the second extension at the lower loads.

The curves shown in Fig. 6 represent the summer and winter cure and processed stock at Tannery 1. The summer stock is more readily extended than the winter stock. The curves shown in Fig. 7 represent the summer and winter cure and processed stock at Tannery 2. This stock gives curves that are similar to the summer stock processed at Tannery 1.

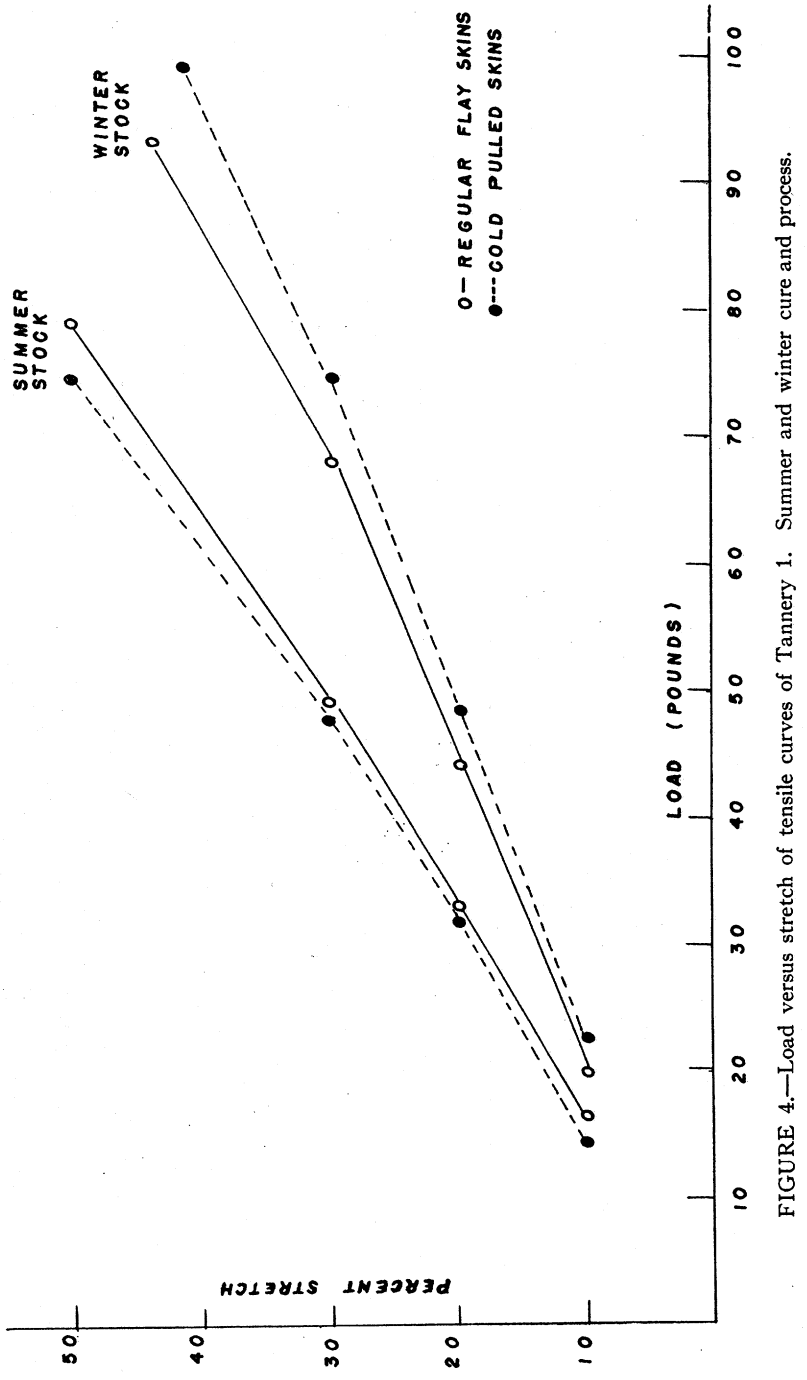


FIGURE 4.—Load versus stretch of tensile curves of Tannery 1. Summer and winter cure and process.

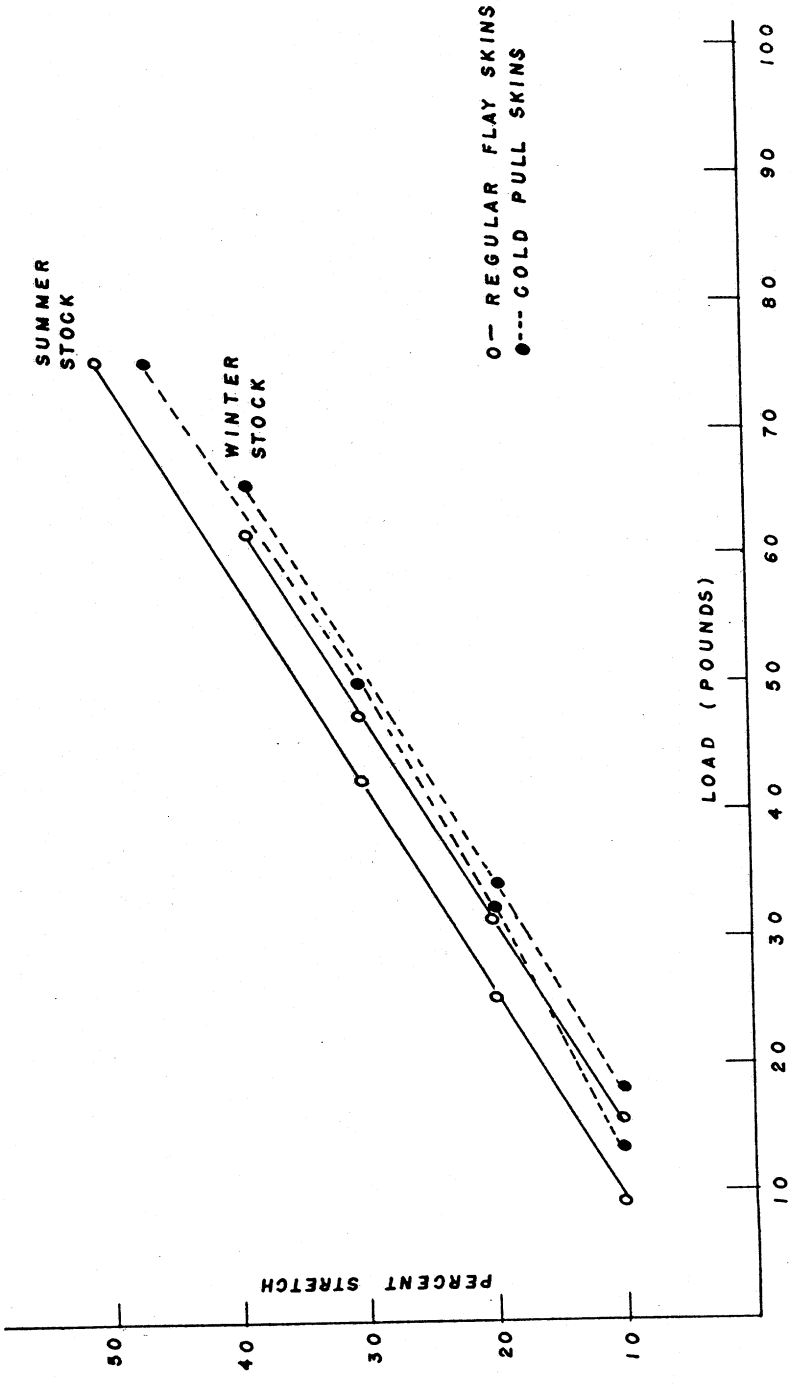


FIGURE 5.—Load versus stretch of tensile curves of Tannery 2. Summer and winter cure and process.

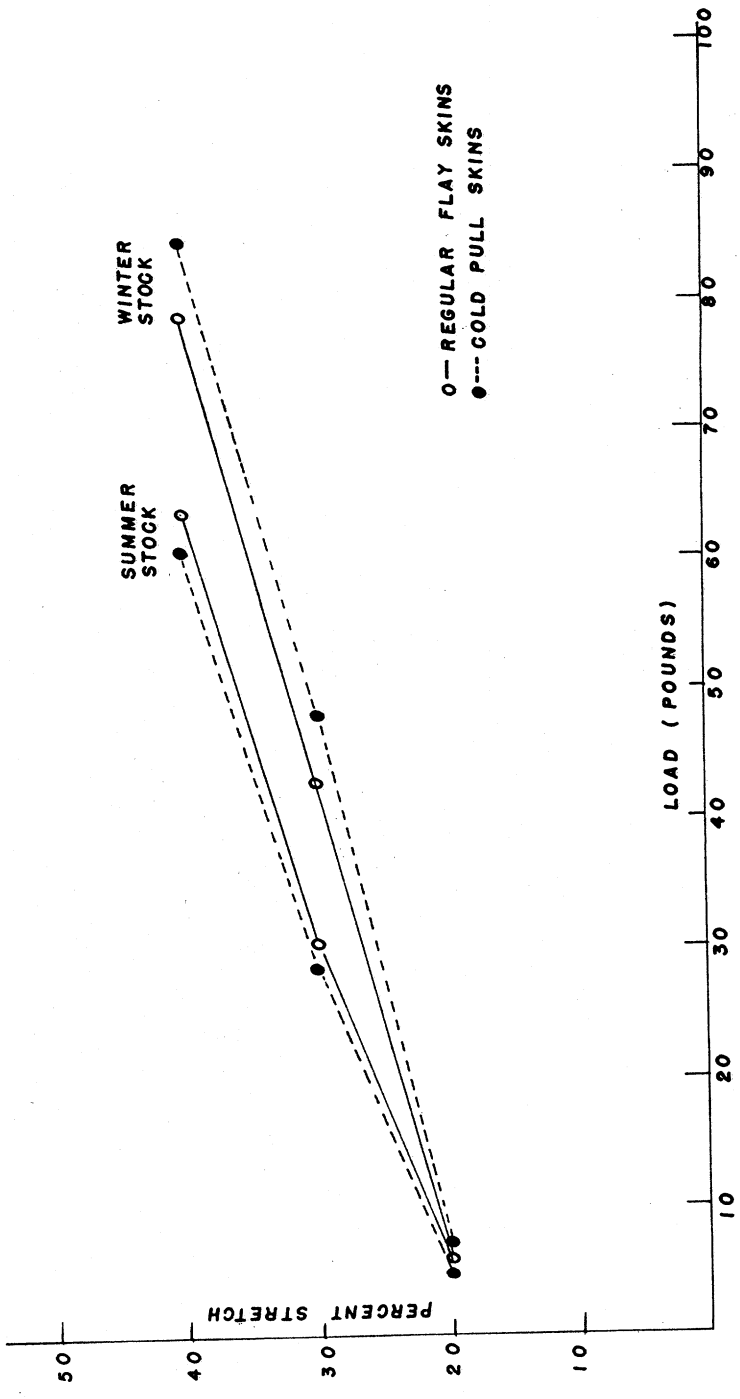


FIGURE 6.—Load versus stretch after elongation to 37.5%, relaxation 1 minute, and stretch to 40%. Tannery 1.

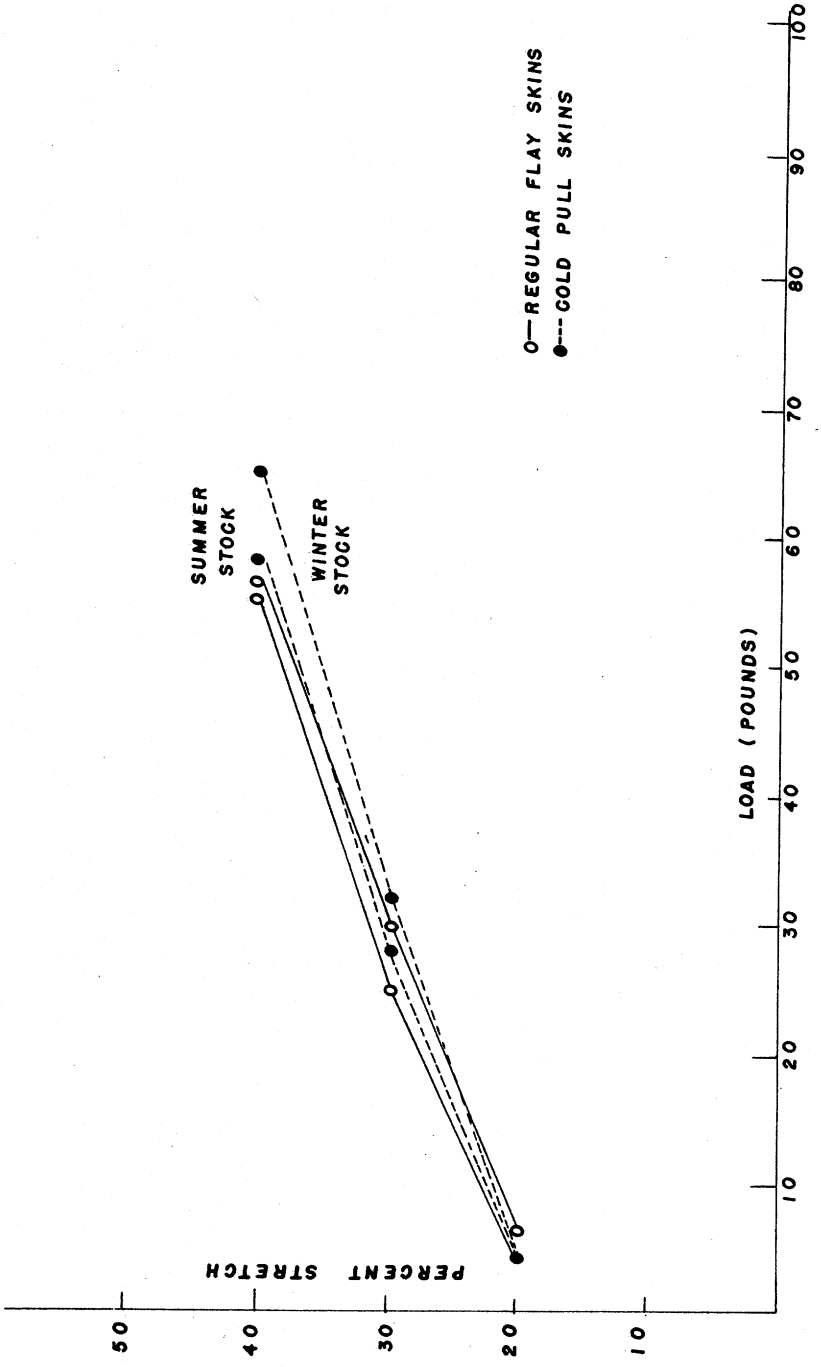


FIGURE 7.—Load versus stretch after elongation to 37.5%, relaxation 1 minute, and stretch to 40%. Tannery 2.

## CONCLUSIONS

Based on visual inspection, microstructure, chemical analyses, and strength of the salt-cured stock, there were no detectable differences in the cold-pull skins versus the regular-flay skins. When the skins were processed into leather at the two tanneries and examined in a manner similar to that used in assaying the salt-cured stock, no differences could be found due to the practices of removing the skins from the carcasses, nor was there any indication that one method was superior to the other relative to leather quality.

The tensile strength of the salt-cured stock was not noticeably altered by processing at either tannery. The leathers made from the salt-cured skins had approximately the same tensile strength in lb. per square inch as the salt-cured skins. Less force was required to break the leathers than the salt-cured skins because of the reduction in thickness to bring the leather to a more uniform thickness. Processing in both tanneries was such that the strength of the salt-cured stock was retained or slightly reduced in one case but not improved.

The only difference found among the leathers was in the extensibility of the winter stock at Tannery 1. The stock was firmer than the other three batches of skins processed and probably reflected the manner in which the calfskins were handled in the tannery.

## ACKNOWLEDGMENTS

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## DISCUSSION

HAROLD R. MILLER, JR. (E. I. duPont de Nemours & Co.): In leather research as well as in other forms of research, a definite result is all-important,

This page to be inserted in Reprint of "Studies of the Quality of Leather made from Calfskins of Current Packing House Practices" from the February Issue of the Journal of the American Leather Chemists Association.



whether it be positive or negative. In this case, your decision depends on which side of the fence you are on—whether you are a tanner or a packer. Although I am no longer in the tanning industry in a production capacity, my sentiments are still along that line. To me this looks like a negative result in that it tends to make me think that here is an opportunity to eliminate another condition prior to the actual tanning operation as affecting results.

I would like to ask Mr. Roddy whether he would like to elaborate on why the one lot of winter take-off skins was different from the other?

MR. RODDY: That gets us into the processing of the skins at the tanneries. As you can see, at tannery No. 2 the skins behaved the same; whereas, at tannery No. 1, during the winter months, the skins apparently were not let out as much as they were during the summer months, or as they were in both cases at tannery No. 2.

This is a reflection, apparently, of temperature conditions in tannery No. 2 during the winter months, and while the liquors—beamhouse and soak liquors—are kept at the same temperature during the winter months, they also try to approach the same temperature during the summer months.

At tannery No. 1, using the type of unhairing process they do, they get less action on the skin during the winter months than during the summer months, which apparently is reflected in the results obtained.

MR. MILLER: From the correlation of analyses between cured stock and finished leather, does there seem to be any hope of eventually setting up a system of inspection, a more foolproof method than just visual inspection, to predict leather quality from the cured condition?

MR. RODDY: During the past few years at the University of Cincinnati we have been analyzing the cured stock as well as finished leather, not only from the standpoint of chemical analysis but also the physical characteristics or strength measurements. And this entire paper indicates that strength measurements can be used as an evaluating tool for strength-stretch measurements.

C. DAVID WILSON (Rueping Leather Co.): Was each skin identified? Did each skin have its own identity?

MR. RODDY: Yes, each skin was identified.

MR. WILSON: What was the degree of correlation, then, skin for skin, between skin strength and leather strength? Or did you perform such a correlation or look for it?

MR. RODDY: We definitely looked for it. I would mention that even on the skins where the original thickness was retained in the finished leather, in some cases we came up with the same strength. In other cases there was reduction of strength.

MR. WILSON: Over all, though, in the lot of 240 skins, is the correlation between skin strength and leather strength a good correlation?

MR. RODDY: A fairly good correlation, yes.

DR. R. M. LOLLAR (Tanners' Council Research Laboratory): I would like to extend that correlation to hides, on which I have done more work. The correlation between hide strength and strength of leather made on the same hides is in general positive and statistically significant. But to a practical extent it is not as good as we would like.

DR. MELLON (Eastern Utilization Research Laboratory): Am I correct in my belief, from what you were saying, that the difference that you describe between the winter stock and summer stock is due to the time at which it was processed in the plant?

MR. RODDY: It represented differences both from the standpoint of the cure and from the standpoint of processing—either summer or winter cure, or summer or winter processing. The summer-cure skins were processed during the summer and the winter skins were processed during the winter.

DR. MELLON: The object of my question was to find out whether the difference was due to processing or whether it indicated a change in the animal. I cannot quite see a change in the animal's skin, whether it was taken off in the summer or winter, because the collagen structure is what you are studying in the leather, and it does not change very rapidly. There is not the rapid change-over of collagen as there is with muscular tissues.

MR. RODDY: I did not go into the chemical analysis this morning, but I can tell you that from the standpoint of chemical composition of both the skins and leathers we would not be able to draw the decisions we have drawn if we had not run the physical tests.